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A Comparative Study in Green Chemistry Education Curriculum in America and China

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Abstract

Green chemistry education offers a solution to our current environmental problems because it provides the opportunity to train future scientists, thus helping move us toward a more sustainable society. In this study, we compared Iran's green chemistry education curriculum with curricula in two developed countries (America & China), using Bereday's method. Our aim was using the experiences of other countries for promoting Iran's green chemistry education curriculum. This paper tries to review, the basic elements of curriculum including logic, objectives, content, teaching methods and assessment in these countries about of this subject. The results showed that there are more similarities in the logic of the curriculum, but the differences are in the objectives, content, teaching methods and assessment. Although Iran has been successful in environmental education but in green chemistry education it requires a revise. The results help program planners to look deeper into curriculum development in green chemistry education. Therefore educational system outputs will be consistent with the community needs.

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1. Introduction

Today's society is becoming more and more environmentally conscious. With the threat of global climate change and the call for movement toward more sustainable practices, the world is being faced with tough challenges .We, as a society, must change our ways, educate our children, and strive to be more aware of our personal actions, and think on a larger scale than that involved with our immediate surroundings. Green chemistry can play an integral role in moving society toward a more positive, sustainable direction (Klingshirn, & Spessard, 2009).

It is known that there is a variety of internal and external factors that determine and shape of the character and content of a country's education system. By having a strong command of these characteristics, we can find clues that help us to evaluate correctly the truths behind the success of effective processes in an education system, in fields from administration to inspection, and from planning to economics. In this increasingly globalizing world, it is inevitable that an educational system will produce common ground with the rest of the world, or those particular methods will be shared by all. This situation requires that the decision making person possesses both global and local perspectives for a reasonable management (Sadullah & Gülsün Atanur, 2011).

In this article, the researcher has scrutinized the status of green chemistry education in the curriculum of two developed and developing countries, America & China using Bereday's method. Bereday proposed a four-stage method. Stages in Bereday's Comparative Method are Description, Interpretation, Juxtaposition and Comparison. The main purpose of the comparative study is carried out to promote Iran's green chemistry education curriculum. In addition this study is not only able to describe green chemistry education derived from countries but also will assist in the development of educational institutions and practices. Finally a comparative study would be able to highlight the relationships between education and society.

After the 1972 Stockholm Conference on the Human Environment and the 1980 World Conservation Strategy of the International Union for the Conservation of Nature, the leaders of our world realized that we need to create an organization whose sole purpose was to raise awareness of the need for sustainable development. Developed countries wanted to reduce the environmental impact of their growth. Green chemistry is discussed in this thread. The concept of green chemistry was introduced in the early 1990s, this approach to the practice of chemistry is still largely absent from the curriculum. Achieving a sustainable planet will require breakthroughs in green chemistry, all of which begin with advances in green chemistry education. In America a non-profit dedicated to green chemistry education and outreach, is actively involved in K-12 outreach and curriculum development and training that it is ahead of all countries. Green Chemistry in China curriculum is an elective course in grades 10, 11, and 12. In Iran, it is compulsory subject in grade 9. However, a common purpose of science education and environmental education is to educate students to be responsible citizens and stewards of the earth (Mageswary. Zurida, 2012). "Green chemistry represents the pillars that hold up our sustainable future. It is imperative to teach the value of green chemistry to tomorrow's chemists". We should also add and to our future politicians, educators, business leaders, financiers, lawyers, economists, health professionals, and so on, for all of us need to think in a sustainable manner. A more selfish reason for chemists to espouse green chemistry is to improve the image of the chemistry profession. For too long chemists have not paid enough attention to the environmental consequences of the compounds that they make and the procedures by which they are made. In order to implant this view in a student's psyche, it is necessary to infuse green chemistry across the curriculum. Educators need to look at all the materials (particularly textbooks) that they use, and consider how they can infuse sustainable chemistry into the discussion (Cann, 2009).

2. Instrument

In this study, the researchers have tried to make use of most recent sources in Persian and English. These sources include books, journals and internet.

3. Comparison curriculum elements in green chemistry education

Green chemistry curriculum in America and China in recent decades has been shaped. This article is an effort at comparative study in elements of green chemistry education curriculum included logic, objects, content, teaching method and evaluation in America, China and Iran (See Tables 1-5).

Table 1. Comparison of the green chemistry education logic in the studied countries

Countries	Logic
America	To handle complaints Environmental Protection Agency USA of schools, Solution problems for humans and the environment, Promote sustainable development objectives, Considerably less traditional approach to social and environmental issues, Reduction of students willing to study the chemistry, Improving the education system, Training of responsible citizens, Ends of natural resources and the necessity of saving (Warner, 2001. Voiland, 2008).
China	The emergence of a highly competitive economy, Development of scientific literacy, Lifelong learning and active participation of students in community development, Environmental degradation by growing chemical industry, High costs, Improving the education system, Education for citizenship, Saving natural resources(Curriculum chemistry, 2007).
Iran	Development of scientific literacy, The move towards industrialization, Concern about environmental pollution, Pushing education towards husbandry skills, Improving the education system, responsible and literate society, Educate trained citizens informed, Ends of natural resources and the necessity of saving (Curriculum chemistry, 2008).

Table 2. Comparison of the most important green chemistry education objects in the studied countries

Countries	Objects
America	To increase safety in schools, Understanding of chemical risks to the planet and its sense of responsibility, To simplify the concepts of chemistry, Encourage students to continue studying chemistry, to minimize waste and decrease costs, Reform of public thinking about chemistry and laboratory, Integration to other science, A green alternative to traditional methods (Klingshirn & Spessard, 2009).
China	To increase safety in schools, Reduce waste and cut costs in laboratories, Development of scientific research, Understanding of chemical effects in the social- economic- environmental and technological, To integration in other fields of science, To replace traditional methods with new methods (Curriculum chemistry, 2007).
Iran	Awareness of the adverse effects of some chemicals used on humans and the environment, safety and environmental protection (Curriculum chemistry, 2008).

Table 3. Comparison of the most important green chemistry education content in the studied countries

Countries	Content
America	Content is organized based on the laboratory approach Green Chemistry, Green Chemistry includes three topics 1-Introduction to Green Chemistry 2-Green Chemistry in industry 3-Replacement experiments (Warner& Anastas, 2012).
China	Content is based on context Subjects, include biodegradable plastics, Green Chemistry, Industrial processes, atomic economics (Curriculum chemistry, 2007).
Iran	Content is organized based on STSE approach, Subjects include: Dirty water, Air pollutants, Methods of collection and disposal of waste, Recycling and saving energy (Curriculum chemistry, 2008).

Table 4. Comparison the most common of green chemistry teaching method in the studied countries

Countries	Teaching method
America	Process oriented, Inquiry-based Learning (N.sbarti, 2011).
China	Process oriented, Training with an emphasis on meaningful learning is a process based approach (Curriculum chemistry, 2007).
Iran	Lectures and question, answer is benefiting (Curriculum chemistry, 2008).

Table 5. Comparison the most common of evaluation in green chemistry education in the studied countries

Countries	Evaluation
America	Evaluation is based on national standards, the final evaluation of students based on laboratory activities (N.sbarti, 2011).
China	Evaluation is included observation of classroom, laboratory activities and exam (Curriculum chemistry, 2008).
Iran	Exam and classroom activities are included (Curriculum chemistry, 2008).

4. Results

Today, green chemistry is the essential component in chemistry education. Green chemistry education in the countries studied is a national process. In the fifth principle of the Iranian constitution, environmental protection has been emphasized. Due to the importance of Green Chemistry Curriculum Development in Iran, so we compared Iran's green chemistry education curriculum with curricula in two countries namely America & China. The results showed:

- Logic: The main logic of green chemistry education in studied countries includes solving the Problems caused by chemistry to the humans and the environment - Ends of natural resources and the necessity of saving - Training of responsible citizens and improving the education system. In addition, the logic of America's are to handle complaints through Environmental Protection Agency USA Of schools, promote sustainable development objectives and reduction of students willingness to study chemistry are mentioned, which is not seen in other countries.
- Objectives: Avoid adverse effects of chemistry on the environment and human - lower costs - improving people's thinking about chemistry - increasing safety in schools - use of renewable resources - reduce waste laboratory - encourage students to study in chemistry - research development - valuing the role of chemists in the community - an alternative to traditional methods with new methods in the curriculum objectives of the studied countries (America and China) is common. But in Iran, to understand the adverse effects of chemicals on humans and the environment we- observe the safety and protection of the environment is shared with other countries. In addition to green chemistry education objectives in America is to simplify the concepts of chemistry and reform of the public misconceptions about chemistry and laboratory are mentioned, which is not seen in other countries.
- Content: In America, teachers have more freedom in choosing the content compared to the other countries (China, and Iran), but general guidelines are provided by the policy makers. The overall organization of content in all studied countries is activity based oriented. In America, content based on the laboratory-oriented and in China is the context-oriented. Green Chemistry in America, covering almost all important concepts of chemistry and in China, it is integrated in all elective units. In Iran, the topic is only mentioned in the section discussing environmental issues. In addition, green chemistry education curriculum content in America is richer than the other countries, but in Iran is limited. In Iran's Curriculum content, climate change and the fuel biodiesel is shared with other countries. In America and China, the 6 principles of green chemistry are introduced to students but in Iran only 2 principles of green chemistry are introduced to students.
- Teaching method: Teaching Green Chemistry in the two countries (America & China) is process oriented. Green chemistry education in America, the emphasis is on laboratory activities. In China, it is problem solving based strategy and working on the project forward. In America, in supporting the training of guidance chemists in schools, workshops, web sites and educational journals are being used. Although the Iran curriculum emphasized an active approach, but in practice, lectures, questions and answer approach is executed.
- Evaluation: Assessment is focused on objectives knowledge, attitudes, and skills in green chemistry subject; But the extent of evaluation in these three countries are different. In America, practical evaluation is dominant and training process is controlled by the inquiry. In other countries (Iran & China), it is not considered for the evaluation of green chemistry standards. Assessed knowledge is dominant in Iran and attitude assessment and process skills are given less attention.

5. Conclusions and recommendations

In conclusion, we have found green chemistry to be an effective vehicle to foster interests in chemistry and the materials sciences. Green chemistry education is essential for a sustainable future where chemistry flourishes green and safe, benign products that are standard. Therefore, comparative study of the basic elements of curriculum in Iran's green chemistry education curriculum with two countries (America & China) showed that there are more similarities in the logic of the curriculum, but the differences are in objectives, content, teaching methods and assessment. The results also showed, green chemistry education curriculum in two countries (China & America), there are more similarities in the logic and objectives of the curriculum, but there are differences in content, teaching methods and assessment. The reasons behind the dissimilarities found between the countries may be due to differences in the curriculum and pedagogical traditions. Iran has been successful in environmental education, but in green chemistry education, it requires a revise. The results help to program planners to look deeper into curriculum development in green chemistry education. Therefore educational system outputs will be consistent with the community needs. By forming productive collaborations between researchers and educators at the frontiers of green chemistry, we anticipate an increasing awareness by the general public and students, of the positive impacts of chemistry on society. Educators must encourage textbooks authors and publishers to integrate green chemistry into the mainstream portions of their books whenever possible. Educators need to suggest to authors ways in which green chemistry can be infused. However, further research is needed before the authors can clarify these issues and reach their final conclusions.

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